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Collecting Maple Sap with Plastic Tubing

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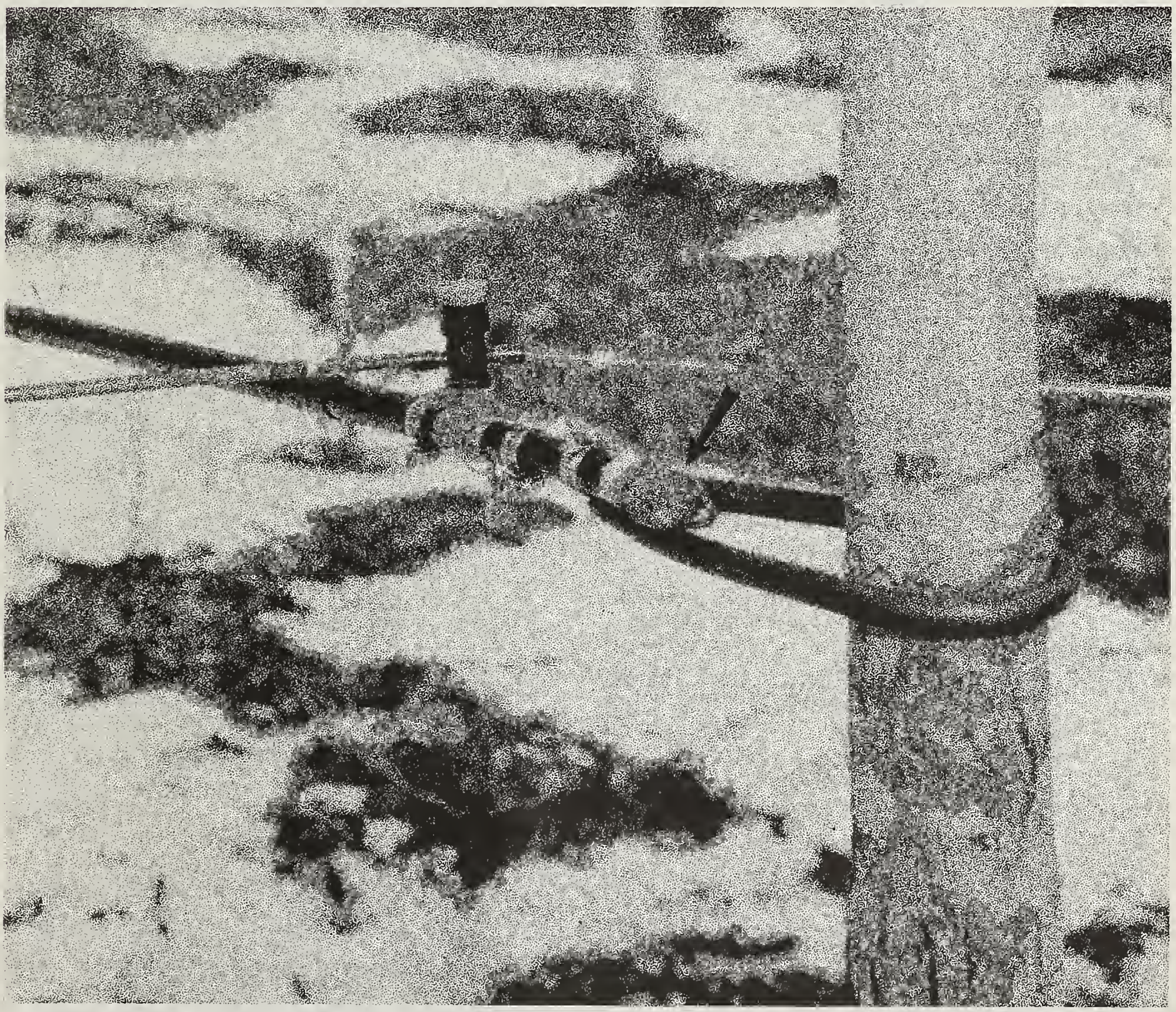

Abstract

Describes how to install and use an unvented aerial plastic pipeline to collect maple sap from tapholes in each tree and carry it to central collecting tanks. A vacuum pump may be connected to the pipeline to encourage sap flow and increase yield. The final step is cleaning the pipeline.

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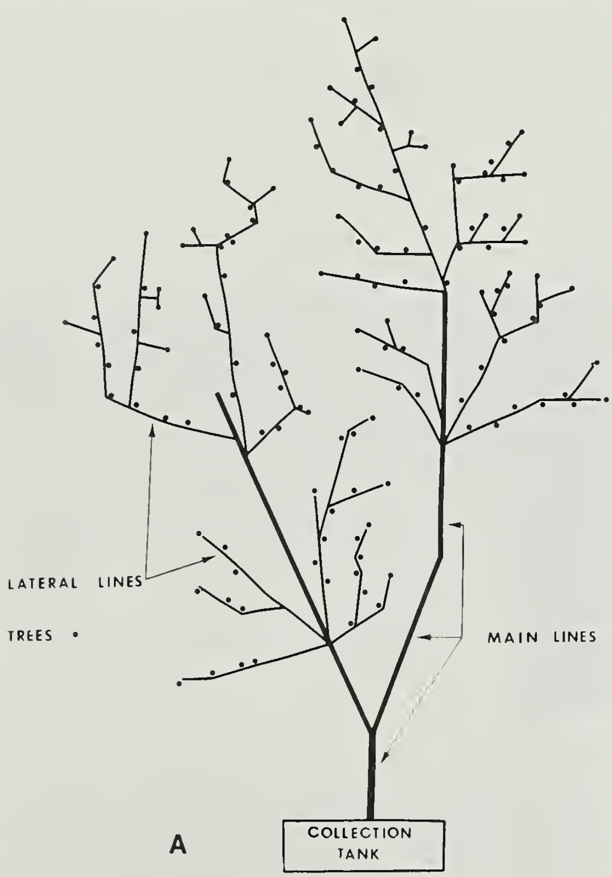
Introduction

In the late 1950's and early 1960's, maple syrup producers began using plastic tubing to collect maple sap for processing into maple syrup. At first, tubing was thought to be an easy solution to the high cost of collecting maple sap. Although many producers did have excellent results with tubing, a large number could not make it work and returned to the traditional sap bucket.

Today there is renewed interest in plastic tubing, due primarily to the success that many producers have had. Also, much more information is now available about the use of tubing.

We know that plastic tubing will produce higher yields of cleaner sap than the traditional bucket method and that it reduces the labor required for sap collecting; together these can reduce the cost of syrup making by as much as 40 percent. Plastic tubing is the most important development in the sugaring industry since early times.

Consulting with producers who are using pipelines and careful planning can prevent many problems. A common mistake is going too large too fast. If possible, one should not install more than about 200 taps initially. The experience gained by working with these few taps and solving the problems encountered will be helpful in expanding the system later.



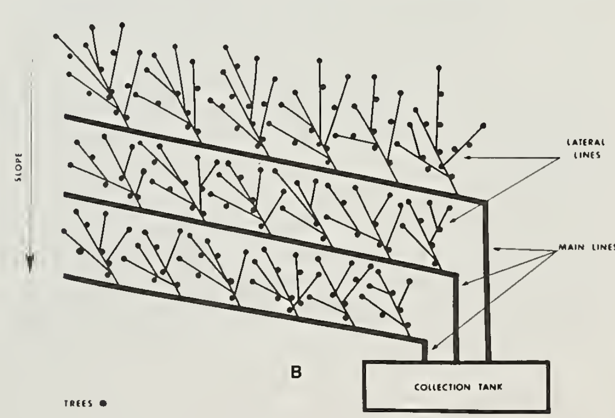


Figure 1.—Two designs of a tubing system for collecting maple sap. In a given sugarbush, any number of designs can evolve. (A) The mainlines are located in the natural draws or depressions. (B) A possible design to gather sap from a side hill.

Plastic Tubing Sizes

Sugar maple sap is collected by a network of plastic lines of various diameters, resembling a number of small streams flowing together into a reservoir (Laing 1971, Smith and Snow 1972). Small 5/16-inch tubing of flexible plastic—the lateral line—is used to carry sap from the spout in the tree to a larger pipe, referred to as the mainline, which carries the sap to the collection tanks. The mainline is of high density plastic and may be from 3/4-inch to 1-1/2 inches in diameter (Fig. 1).

The flow rate of sap through the mainline is directly related to its diameter and slope. In the lateral line, in addition to slope, flow rate is dependent upon the number of tapholes attached to the line. For example, the 5/16 lateral lines can carry sap from 50 taps on 5 percent to 10 percent slopes; the size of the mainline to drain the lateral lines depends on the number of lateral lines feeding into it (Table 1).

Table 1.—Number of tapholes a plastic pipe can accommodate (Smith 1971) (Assumes a peak flow of 1/2 gallon of sap per taphole per hour)

Slope (percent)	Plastic pipe diameter in inches		
	3/4	1	1-1/2
6	700	1300	4000
10	900	1700	5000
15	1100	2100	6000
20	1300	2400	7000

Table 1 identifies the number of tapholes that a 3/4-inch, 1-inch, and 1-1/2-inch mainline can handle on different slopes. A 3/4-inch mainline installed on a 6 percent slope can transport sap from 700 taps. Thus a 3/4-inch mainline is not large enough to carry the peak flow from a sugarbush of 1,000 taps on a 6 percent slope. The lower end of the mainline will need to be increased (to 1 inch as a minimum) to handle the extra 300 taps, if the mainline is to function efficiently without being overloaded during the peak flow period. Another choice could be to install a 1-inch mainline throughout to serve the 1,000 taps. This would ensure enough capacity during peak flows and provide an opportunity to expand the system to handle more taps later.

The number of taps recommended by Smith for the various diameters of mainline in Table 1 may appear high compared with the number of taps suggested by other authors. Moulton and Franz (1979) suggest 500 taps for a 3/4-inch mainline, 1500 taps for a 1-inch line, and 3000 taps on a 1-1/2-inch mainline, regardless of slope. They believe that mainline blockage is a major problem that can be corrected by having the mainline serve fewer taps than recommended by Smith.

Smith's recommendations are based on the assumption that the maximum sap flow is 1/2-gallon of sap per taphole per hour, but the actual flow varies widely. Therefore, if the choice is between a 3/4-inch and a 1-inch line, choose the larger size if the smaller line is close to capacity. The function of the mainline is to carry sap away from the laterals without impeding the flow. This can only be accomplished if the mainline is large enough to handle the flow when it and the natural vacuum are at their peak.

Tubing System

The most efficient tubing installation is a closed leak-free system hung or suspended from tree to tree with enough constant slope for the sap to flow freely to a collection tank.

If the sugarbush is on a hill, installing tubing so it slopes downhill is simplified. On flat terrain, an artificial gradient must be created by raising the ends of the lines farthest from the collection tank, both laterals and mainlines.

A closed tubing installation can increase sap yield by over 40 percent compared to a vented line system because of the natural vacuum or syphoning effect created by the weight of the sap in the tubes. Every system should be installed to create the conditions for optimum development of natural vacuum (Koelling, et al. 1968). This will not only ensure increased sap yield without pumping, but will increase production with a pumping unit.

A natural vacuum system requires a good head of sap, a leak-free system, and a free-flowing line with no sags. The vacuum produced is directly caused by the head or weight of sap in the line. This means that each lateral line should have at least 50 taps on slopes of 5 percent to 10 percent. On steeper slopes, 51 to 80 taps will not overload a line and will develop good vacuum. On shallow slopes, less than 5 percent, the lateral line has a lower carrying capacity, a lower vacuum potential, and can serve fewer taps (10-40) (Morrow 1974).

Although laboratory tests show higher carrying capacity for 5/16 laterals on steeper slopes, in practice more than 50 taps are rarely installed on a line. This is because of the difficulty of taking down, cleaning, and reinstalling large rolls of tubing. A 50-tap roll is about as large a roll as an operator would want to handle. This should not be a limiting factor for operations where the tubing is left hanging; in these, the operator should use the full carrying capacity of the 5/16-inch tubing on steeper slopes.

Leaks in lateral lines cause the loss of both natural and artificial vacuum and result in low sap yields. Most leaks are caused by failure to push the tubing over the collar of the fitting and can be corrected easily (Fig. 2). Persistent leaks at junction points or at joints subject to heavy tension can be corrected by the use of clamps.

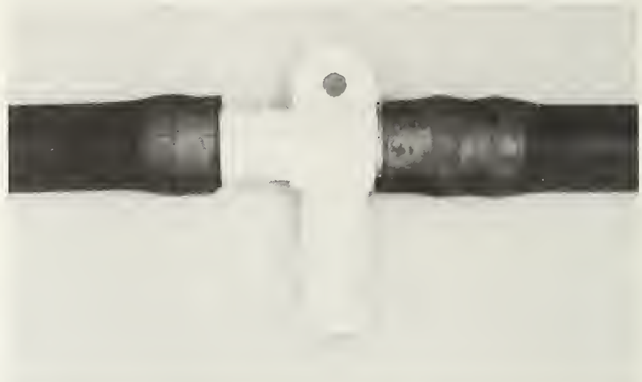


Figure 2.—To avoid leaks or separation of the line when it is full of sap, make good connections at all junction points, pushing the tubing all the way over the collar. The tubing on the left side of the "T" is not properly fitted.

Sags in the line restrict rapid, continuous flow of sap, reduce natural vacuum, and prevent line drainage after a run, which lowers syrup quality (Walters and Yawney 1978). A well-tensioned line ensures a rapid flow of sap, the development of good natural vacuum, and the production of high quality sap (Fig. 3) (Lancaster and Walters 1974). It may be necessary to retighten the line during the sap season if excessive sag develops.

Figure 3.—(A) A well-tensioned line with no sags. (B) A line sagging to this extent will not drain after a sap run. Trapped sap either freezes and restricts flow at the beginning of the next run or spoils and contaminates a portion of the next run.

Installing the Mainline

The starting point in the installation of a tubing system is locating the mainline (See Appendices 1 or 2 for supplies needed). An examination of the sugarbush will quickly reveal the best location for the topography and the placement of the collecting tanks. Ideally, a collection tank should be in the sugarhouse. As this is impossible in most cases, the tanks are usually located at the lowest easily accessible point in the sugarbush and as close to the sugarhouse as possible.

A gradient of at least 3 percent is essential in all mainline installations, whether the system is on hilly ground or flat terrain (Moulton and Franz 1979). This is to ensure complete drainage of the lines at the end of each run. On flat ground, the slope of the mainline is created by raising the end of the mainline farthest away from the collecting point 3 feet or more for each hundred feet of mainline.

Once the location of the mainline has been identified, the next step is to mark it with tree-marking paint, axe blazes, or plastic ribbon. In this process, the length of plastic pipe needed can be determined by measuring or pacing the distance from the collecting tank to the top end of the line.

Mainlines should be suspended above the ground; ground lines invariably get covered with snow, freeze quickly, and thaw very slowly. Also, it is difficult to install a ground line without dips or low spots that hinder complete drainage of the line at the end of a run.

The mainline may be suspended on a 9-gauge steel wire or stretched and hung by wire cable grips at each end (Fig. 4).

Figure 4.—Electric cable grips should be 1/8 inch larger than the pipeline. With the grips, the mainline can be tightened as needed during the sap season.

Even though both systems will work well, if the intent is to leave the mainline hanging permanently, suspending it from a wire is to be preferred (Fig. 5). It is important that the mainline be properly supported along its entire length. Supports, either trees or posts, should be about 50 to 60 feet apart. The pipeline should be properly tensioned to avoid sagging when the line is full of sap. A "come-along" or fence stretcher can help achieve the desired tension on both the pipeline and the carrying wire.

Figure 5.—Mainline hung on a 9-gauge wire is solidly attached by bag ties at about 2-foot intervals. A bag tie twister is essential for installing them.

The final step in installation is to plug the upper end of the mainline. The plug is secured with a steel clamp (Fig. 6).

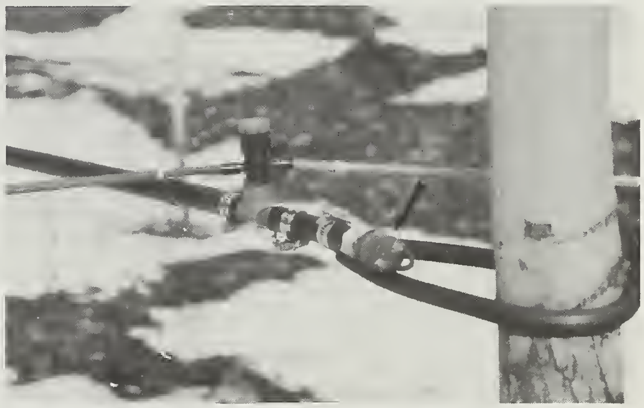


Figure 6.—To prevent air leaks, the upper end of the mainline is closed off with a plug that is sealed in position with a clamp. Without the clamp, the back pressure in the line can blow the plug out. Note the attachment of the mainline to the support tree. The 9-gauge wire is inside a rubber hose to protect the tree.

Installing the Lateral Line

After the mainline is in place, walk up alongside of it and pick out natural groups or clusters of trees that provide the shortest drainage pattern to the mainline. Install a manifold or a 4-way "Y" in the mainline at these points.

Start installing the lateral lines by securing the 5/16 tubing to a tree closest to the manifold in the mainline (Fig. 7). Lead the tubing out, winding it from tree to tree. Pull the tubing tight so that the pressure holds it in place against the trees. As you string the line out, avoid excessive bends or crooks by proceeding in a reasonably straight line up the hill and avoiding isolated side trees outside the cluster. These trees off to one side can be reached by individual branch lines installed during the tapping operation.

Figure 7.—To start installation of the 5/16 lateral line, secure the line to the closest tree on the uphill side of the manifold in the mainline.

Count the number of taps on the line as the lateral line is strung out. When the carrying capacity of the line has been reached, 50 to 80 taps depending on the slope, tie its end to a tree (use bailing twine) to keep the tubing taut and in proper position. If there are more trees to tap beyond the end of the line, these can usually be reached by another lateral line from a manifold further up on the mainline. In some instances, another mainline may be necessary.

On the way back to the mainline to start another lateral, examine the line just hung to make sure it has a rapid, uniform downward slope. Make temporary adjustments to eliminate flat spots and sags, using twine, props, and tree saplings for support. After the trees have been tapped and the tubing line is fixed in place, these adjustments can be made more secure.

The placement of the mainlines and lateral lines can be done any time before the sap season. The best time is after the leaves have fallen, when foliage does not block visibility of the trees and slope of the land. Most systems are placed between November and March. This is one of the advantages of tubing; it can be installed at times that do not interfere with tapping and other activities. Also, it allows the operator to spread his work over a longer period.

Both the mainline and lateral lines may be left hanging permanently or removed each year. Permanent installations are subjected to damage from falling trees, rodents, and people, and will deteriorate faster if left to the elements.

Tapping

After the lateral lines have been installed, the trees can be tapped. Because the closed, unvented tubing system minimizes drying of tapholes and the entrance of microorganisms, tapping can be started as early as the first part of February—even earlier in the southern part of the maple range.

The taphole is located about 18 inches above the lateral line. Use a dropline to locate this point (Fig. 8). This keeps the lines at approximately the same slope and minimizes sagging when they are full of sap. Tapholes are usually 4 to 6 feet above the ground, but their height can be changed to keep the slope of the lateral line constant.

Figure 8.—The dropline, with a spout on one end and a connecting tee on the other, must be at least 18 inches long. This allows the sap to fall away from the spout quickly and avoids reabsorption or back pressure. Also, rehanging the tubing the next year with new tapholes is easier with droplines of adequate length.

Tapholes are drilled either by hand with a carpenter's brace or with a portable gasoline or electric drill (Fig. 9). In drilling tapholes,

a. Use a sharp 7/16-inch drill bit.
b. Drill to a depth of 2-1/2 inches or until dark wood is reached (Walters and Shigo 1978b).
c. Never tap a tree above or below a recent tap. Make the taphole at least 4 to 6 inches to one side of the previous year's taphole. If this is impossible, the new taphole can be as close as 1 inch from the old taphole without a reduction in sap and sugar yields (Smith 1971).
d. Drill the hole at a slight upward angle so the sap will flow out of the hole easily (Fig. 10).

Hollow trees can disrupt natural vacuum in the tubing system. Each tap should be checked for leaks by seating a spout, with a dropline attached, into the taphole. Suck on the dropline as you would on a beverage straw. If a vacuum is created, the attachment is leak-free (Smith and Snow 1972). If air is drawn, which is possible if the tree is hollow, then there is a leak and it is necessary to bore another hole. The new hole should be less than 2-1/2 inches, possibly 2 inches or less, deep to avoid the hollow section of the tree.

The 18-inch dropline (usually preassembled) is installed as part of the tapping operation. For a tree big enough to have more than one taphole, a dropline harness may be used so that only one "T" fitting is needed in the lateral line (Fig. 11). The spout is tapped into the taphole cautiously to avoid splitting the bark (Fig. 12). There is a definite solid feeling when the spout is firmly seated. Extremely cold days should be avoided because bark splits easily in air temperatures of 25° or lower (Walters 1978). If trees are tapped on very cold days, the spouts should be tapped only enough to hold them in place until they can be firmly seated on a warm day.

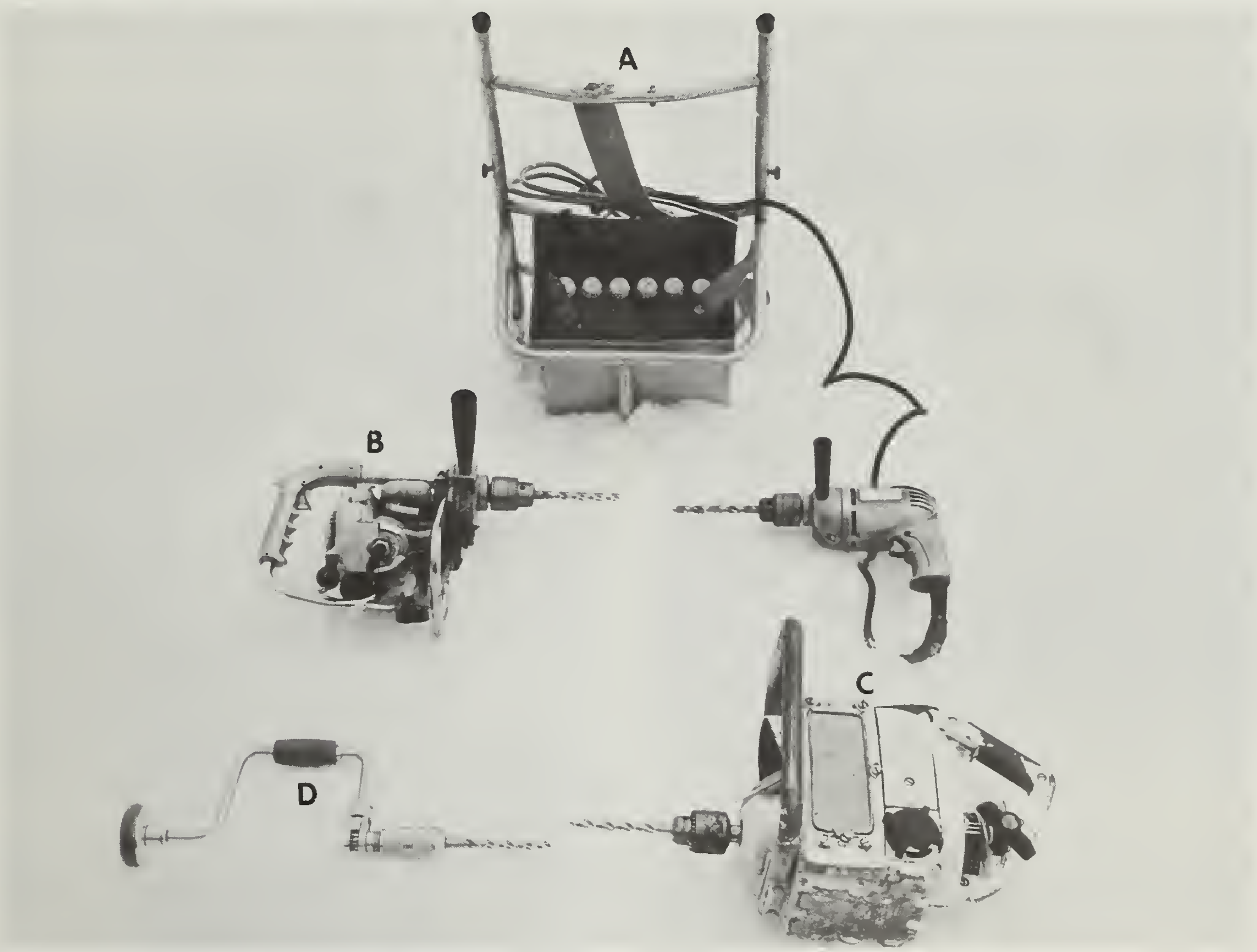


Figure 9.—Various types of tappers: (A) battery-powered drill with backpack harness; (B) gasoline power drill; (C) chainsaw with drill chuck attachment in place of bar and chain; and (D) carpenter's brace and bit.

Figure 10.—Drill the taphole at a slight upward angle so the sap will flow out of the hole easily. Proper safety equipment includes a hardhat, eye shield, and hearing protection.

Figure 11.—A dropline harness for a tree with two taps.

Figure 12.—A wooden or rawhide mallet is good for seating the spout.

Joining Droplines to Lateral Lines

Connecting the droplines to the lateral lines holds the line in place. The connection must be made while the lateral line is under continuous tension. Before joining the lines, stretch the tubing between the tree just tapped and the next one to be tapped. Stretching is especially necessary for new tubing.

Start at the uppermost tree. Secure the lateral line as shown in Figures 13 and 14. Proceed to the next lower tree, stretch the lateral line, cut the lateral line, holding both ends in place, and fit the tubing ends onto the tree at the end of the dropline, without losing the tension in the lateral line. This procedure is followed throughout the length of each lateral line.

Joining droplines to the lateral line is usually done by two people, one to hold the lateral line in tension after it is cut and the other to connect the dropline to the lateral line (Fig. 15).

Figure 13.—One method of securing the uppermost end of the lateral line. The tap is turned in the direction of the pull of the line.

Figure 14.—Another method of securing the upper end of the lateral line is to connect the dropline to the lateral line with a coupling that can be nailed to the tree.

Figure 15.—Joining the dropline to the lateral line. The lateral line is held in position and cut, and the tubing ends are fitted onto the tee at the end of the dropline.

One person can connect droplines to the lateral line while maintaining a good tension on the line by using two pairs of small locking pliers, with the jaws wrapped with friction tape to protect the tubing, tied together with strong cord about a foot long (Fig. 16).

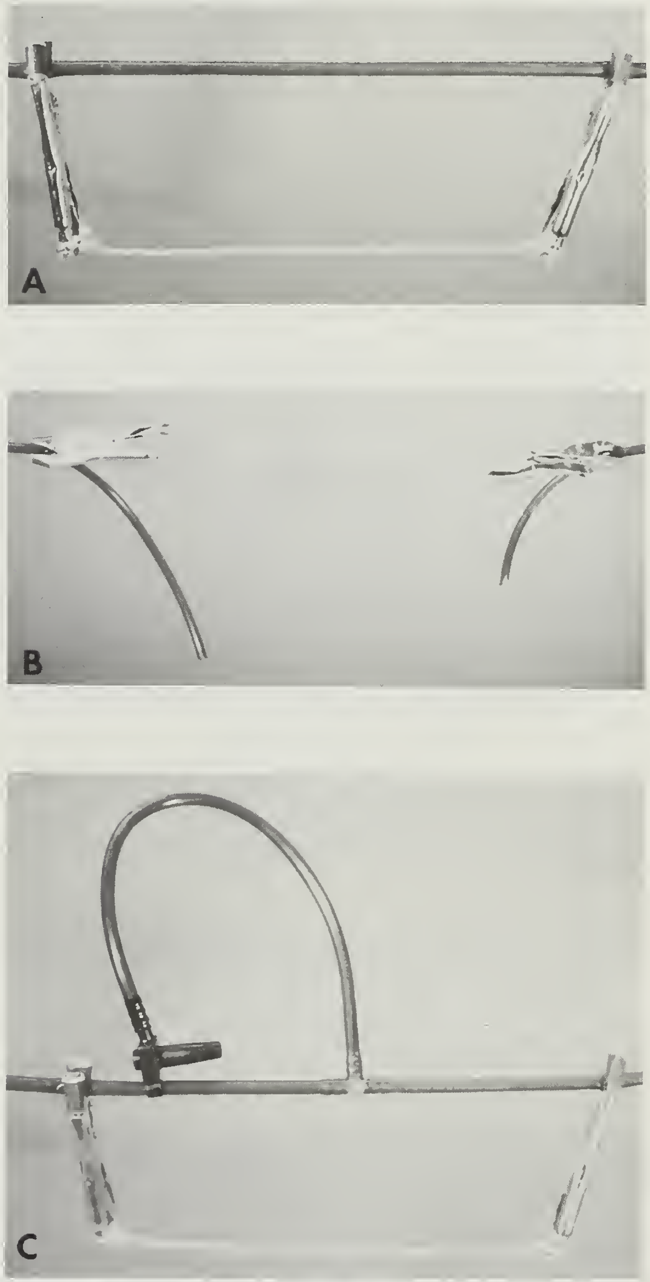


Figure 16.—This homemade tool enables one person to connect droplines to the lateral lines without losing tension in the lateral line. The pliers are locked in position on the line; the tubing line is cut, but held in place by the tool; and the dropline is attached. Then the pliers are removed.

There are several methods of installing tees and connectors in the 5/16 tubing in cold weather. A modified tubeless tire probe (Fig. 17) is less cumbersome to use than the other methods. The tubing end can be stretched enough to fit over the collar of the fitting without warming the ends.

Another way is to warm and soften about 1/2 inch of the ends of the tubing so that it will expand and slide over the collar of the fittings easily. Many devices can be used, ranging from a vacuum bottle of hot water to small, insulated charcoal or oil-fired water heaters that are easily carried in the woods.

Figure 17.—A tubeless tire probe, with jaws that open with applied pressure, is effective for stretching the ends of the 5/16-inch tubing without warming the ends. The tool is modified by filing and rounding the sharp edges on the outside of the jaws to prevent damaging the tubing.

The final step in installing the lateral line is connecting the 5/16-inch tubing to the larger mainline manifold. The lateral line should approach this junction at the angle of the manifold. The two lines are brought together in a smooth curve rather than at an abrupt angle that could restrict the flow (Fig. 18).

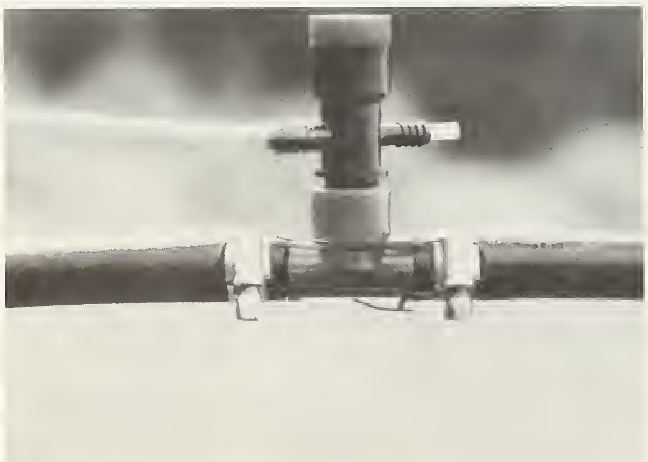


Figure 18.—When joining lateral lines to the mainline, be careful not to kink or crimp the lateral line.

Supporting the Lateral Line

To preserve natural vacuum, avoid leaks in the tubing line, and prevent the tubing from pulling apart when it is full of sap, particular attention should be given to all connections and to the suspension of the line. Tubing must be pushed all the way over the shoulders of all fittings. To develop a rapid, unobstructed flow of sap, sagging lines and kinking or crimping of droplines should be avoided. Maintaining proper tension on lateral lines, especially when they are heavy with sap, requires that the lines be supported—particularly on long spans—by wire, string, props, saplings, or trees (Fig. 19).

Figure 19.—If the distance between trees is so great that tubing will sag badly, the tubing should be supported. A tubing support bracket can be used or the tubing can be supported with bailing twine.

Vacuum Pumps

Research has shown that plastic tubing systems will yield more sap than buckets; an unvented, closed system will yield more than a vented system (Blum 1967); and a vacuum pump attached to a tubing system will increase sap yield even more—by 100 percent or more (Morrow and Gibbs 1969).

In each sap season, there are a number of days when conditions are almost right for a run. That is, the tree's internal pressure is about equal to the atmospheric pressure. This also occurs for a time at the beginning and end of each sap run. During these times sap flow can be induced or prolonged by vacuum pumping.

An effective vacuum system produces a gauge reading of at least 10 inches of mercury at the far end of the tubing. A 15-inch vacuum level at the end of the system will increase sap yield, but the volume is not significantly greater than at the 10-inch level (Walters and Smith 1975).

Because there is a loss of vacuum to friction in tubing lines, gauge readings should be made at the ends of the pipeline system farthest from the pump. Also, to develop a vacuum level of 10 to 15 inches at the taphole requires 20 to 25 inches at the pump (Walters and Smith 1975).

Several types of pumps can meet the needs of small and large producers. The jet water pump and the tube pump (peristaltic action type) are the least expensive and are well suited to systems with about 500 to 1500 taps. More expensive vacuum pumps are available to the larger producer with 2000 taps or more (Fig. 20). These are units of 3 or more horsepower with an output of 25 to 30 cubic feet per minute or more.

Because effective vacuum pumping requires a closed leak-free tubing system, it is essential that the lines be inspected frequently to detect leaks that could reduce the vacuum level in the line.

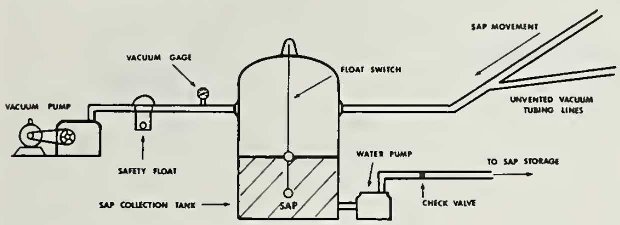


Figure 20.—The basic design of a vacuum pumping installation. The float switch activates the water pump to empty the tank when it is full of sap.

Washing the Tubing

It is important to wash the tubing as soon as possible after the last run to prevent bacteria from growing inside the lines and to flush out foreign deposits. A mixture of 1 gallon of household bleach to 19 gallons of water is usually used (Appendix 3). The cleaning solution must contact all the internal parts of the pipeline, including the mainline, lateral lines, droplines, spouts, manifolds, and connectors. There are several ways of getting the fluid into the lines to clean them.

If the tubing system is to be left hanging in place, solution can be pumped through the lines with a small pumping unit at the collection tank. As the cleaning solution is being pumped into the system, individual spouts are removed from the trees; a stream of solution is allowed to escape from each spout and when the solution becomes clear, the spout is capped. This process is continued throughout the entire length of the system. The cleaning mixture is allowed to stay in the lines for a short period, then the lines are drained and capped again to remain hanging. It is important to cap all spouts left hanging; an open spout is an invitation to wasps to pack these openings full of mud and lay eggs in them. These mud plugs are difficult to find and remove (Fig. 21).

If the lateral lines are taken down each year, they can first be washed in place, using the above procedure or a variation of it, or the cleaning solution can be pumped through the tubing after it is removed (See Appendix 3). Another way is to use the reel-type plastic tubing washer (See Appendix 4). Coils of tubing are placed on the spool and then slowly rotated. The line ends, spouts, or open tees pick up the solution, and the constant rotation causes the solution to move through the lines. The solution is removed by rotating the spool on the upper supports, out of the cleaning solution. Usually 30 minutes or more are required in each location.

Figure 21.—The droplines of a lateral line left hanging should be securely attached to the lateral line. A dangling dropline attracts rodents that can cause damage. Also, spouts should be sealed with plugs or caps. Spouts make ideal homes for mud wasps.

A simple frame is usually used to roll the lines in the field so that the rolls are uniform in size and will easily slide on to the washing spool.

This type of washer is simple to use and a time saver. The only limiting factor is that the rolls should not be too large, i.e., they should hold the tubing for about 50 taps. Some producers remove the droplines from the lateral lines before washing while others do not. The lines are adequately washed either way.

If the lines are removed each year, it is necessary to identify the spool and its location in the sugarbush by tagging it with some sort of coding or mapping system. This is important so that the tubing lines can be reinstalled in the same location each year.

Paraformaldehyde-Treated Tapholes

Paraformaldehyde pills inhibit the growth of microorganisms that can obstruct the sap flow. Recent research indicates that the repeated use of paraformaldehyde in tapholes can cause decay in sugar maples.

One of the advantages of the tubing system is that the paraformaldehyde pills are not required to increase yields. The tapholes are not exposed to invasion by microorganisms when the system is not vented (Walters and Shigo 1978a).

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Appendix I
Parts of the Tubing System

Figure 22.—Various designs of plastic spouts.

Figure 23.—Spout caps or plugs are necessary in flushing the line, and if the line is left hanging.

Figure 24.—5/16-inch tees to connect the dropline to the lateral line. The hole in the tee on the right may be used to nail the tee in position when needed. The tee on the left has a projection to which a spout can be attached; it can serve as an excellent spout plug and holder.

Figure 25.—5/16-inch connector used to join sections of lateral line when it is necessary to lengthen or shorten the line. One design includes a hole for nailing.

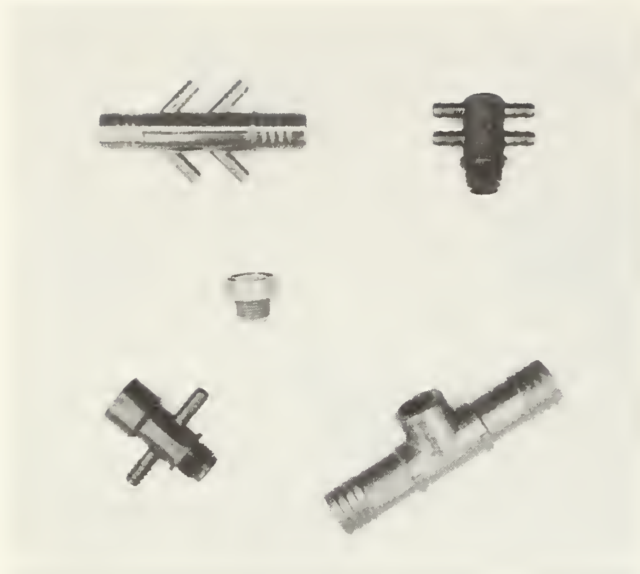

Figure 26.—Manifolds used to connect the lateral line into the mainline. They are the same size as the mainline and can accommodate two or more lateral lines.

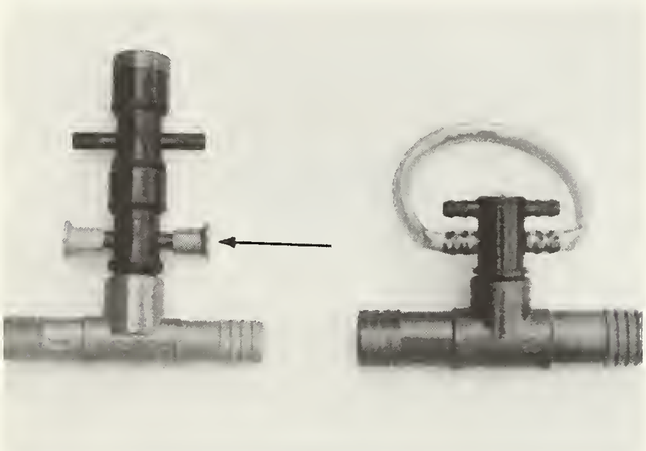

Figure 27.—Caps to seal off the 5/16 branches not in use on the manifold. Two unneeded branches can be sealed off with a short piece of 5/16 tubing as on the manifold to the right.

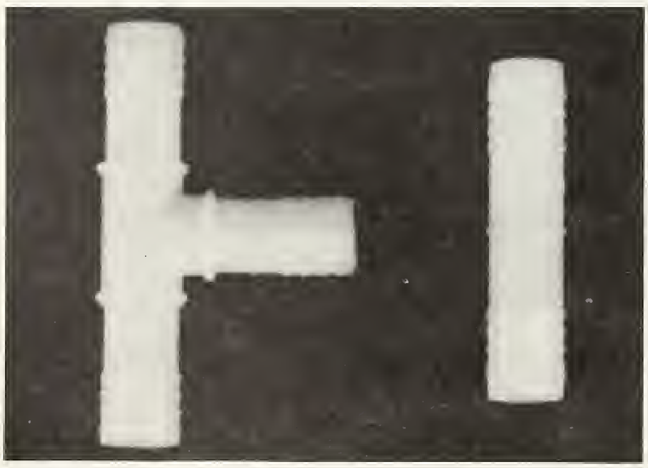

Figure 28.—Mainline connector and tee for joining mainlines.

Figure 29.—Mainline end plugs seal off the upper end of the mainline. These are clamped in position with stainless steel clamps.

Figure 30.—The essential tools for installing the tubing system include, from left to right: spring clip pliers, mallet, screwdriver, two pairs of locking pliers, tire probe (modified), bag tie twister, and anvil pruning clippers. A carpenter's apron is handy for carrying tools and supplies.

Appendix 2

To determine the supplies needed for the installation of a tubing system, the first step is to establish the number of taps in the sugarbush that are to be connected. With this information, quantities can be estimated for:

1. Spouts—the same as the number of taps with a few extras.
2. 18-inch droplines—same as the number of spouts. Most of the single tap droplines, with a tee on one end and a spout on the other, should be assembled before going into the field.
3. Plastic 5/16-inch tees—same as the number of taps, plus 25 percent.
4. 5/16 connectors or couplings: 2 dozen per 1,000 taps. For the mainline, two connectors (the same size as the mainline) for each roll of pipe.
5. Manifolds, one per 100 taps.
6. Stainless steel clamps, two per manifold, plus 50 percent.
7. 5/16-inch lateral tubing—15 feet per tap.
8. Storage tanks—a capacity of 2 gallons per tap.
9. 9-gauge wire—enough to support the entire length of the mainline, plus 200 to 300 feet.
10. Bag ties—enough to attach the mainline to the carrying wire at 2-foot intervals. Electrician's tape can be substituted for the bag ties.
11. 5/16 spring clips: a token supply to correct troublesome connections in the lateral lines.

Appendix 3
Tips for Washing Tubing

If plastic tubing is left too long (several days) in a chlorine solution, a white deposit may form on the walls of the tubing. This will be washed out by the next season's sap flow, but it is better to avoid it.

Chlorine from any washing solution is boiled off in the evaporator, but too much of it may darken the syrup.

An adequate solution for washing is 1 gallon of Clorox to 19 gallons of water.[1] If laundry bleach other than Clorox is used, check its sodium hypochlorite content. Clorox contains 5.25 percent sodium hypochlorite; other brands may contain more or less, and the ratio of bleach to water may need to be changed.

Dry chlorine formulations,such as those used for treating swimming pools, may be a less expensive source of chlorine than liquid bleach. Agway's "Pennswim Sentry," for example, contains 65 percent sodium hypochlorite. To make a solution comparable to Clorox, use 3/4 cup of Pennswim Sentry to 19 gallons of water.

The cleaning efficiency of the bleach solution can be increased by adding a water softening agent such as Calgon. The amount to add is determined by the hardness of the water (see directions on the package).

WARNING: Chlorine products are irritants and should be used with **CAUTION**. In addition, dry chlorine formulations may be extremely flammable. Read the labels of any such products you use and follow the precautions recommended.

Appendix 4
Reel Type Plastic Tubing Washer (Staats 1973)

This device is homemade from materials that are easily obtained at little or no cost. The parts listed below are indexed to Figure 31.

- A — Small electric motor, 1725 r/min. 1/4 hp., with a 2-inch V-belt pulley.
- B.— Bicycle wheel (20-inch) used as a pulley on the reel shaft. The reel shaft is 1-inch galvanized pipe with the wheel spot-welded to it. This pulley system reduces the reel speed to approximately 40 r/min.
- C — Double pulley from an electric clothes dryer. Many brands have pulleys of this type and there are many discarded dryers.
- D — Reel in draining position. The support pivots on one end so that the washing reel can be moved from the washing position (lower support) to the draining position shown.
- E — Support for reel in washing position.
- F — Pivot arm and motor support. This can be raised or lowered to turn reel in either draining or washing position. Weight of motor maintains tension on V-belt.
- G — Washing tank—the tubing washer size can be adjusted to fit a tank that is already on hand. This one is a 400 gallon stock-watering tank.

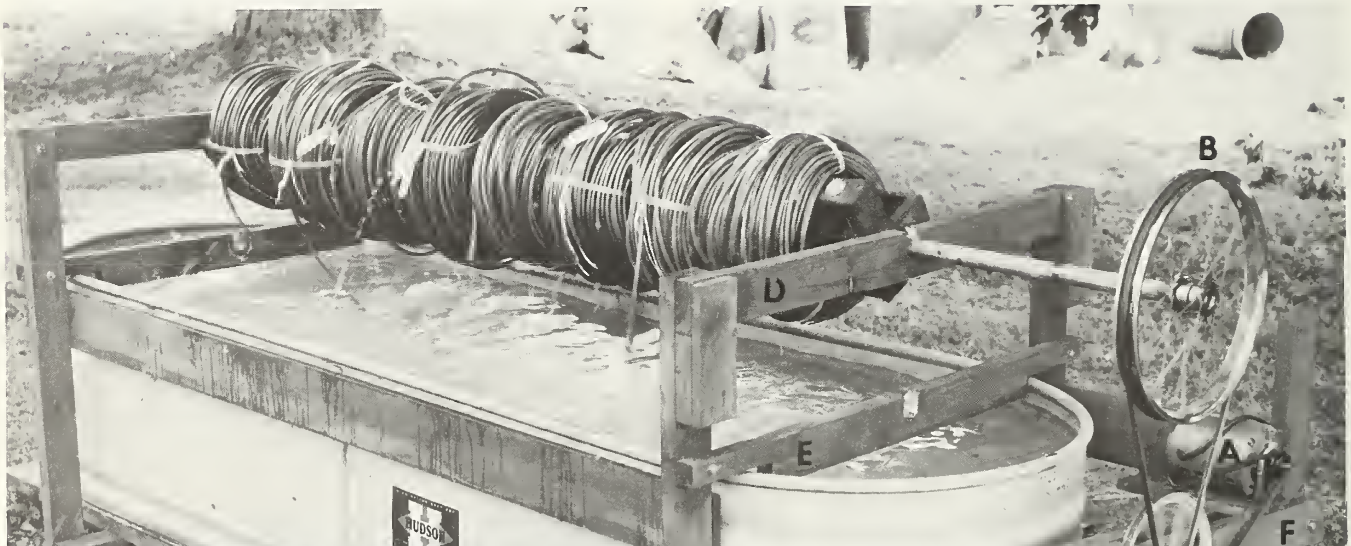

Figure 31.—A homemade reel-type plastic tubing washer.